Mem. nat. Mus. Melbourne, 18, 1953.

THE RELATIONSHIP OF *CYCLAMMINA*-BEARING SEDIMENTS TO THE OLDER TERTIARY DEPOSITS SOUTH-EAST OF PRINCETOWN, VICTORIA

By George Baker, M.Sc.

Introduction

Dr. I. C. Cookson has recently recognized and described (this volume, pp. 107-123) a number of marine and terrestrial micro-organisms from a deposit of carbonaceous sandy shale outcropping in the sea cliffs approximately three-quarters of a mile south-east of Point Ronald, at the mouth of the Gellibrand River, near Princetown, parish of Latrobe, counties of Heytesbury and Polwarth, Victoria. Samples of this deposit were treated by the author in 1942, and the residues from hydrofluoric acid digestion submitted later to Dr. Cookson for investigation.

The carbonaceous sandy shale was re-examined in the field in December, 1951, with a view to seeking further evidence for comparison with the marine, carbonaceous beds at Demon's Bluff near Anglesea and at Point Addis midway between Torquay and Anglesea, Victoria. Dr. Cookson describes a number of similar marine and terrestrial micro-organisms from the carbonaceous sandy deposits comprising the Anglesea cliffs.

As a result of the discovery of other marine fossils during re-examination of this deposit, much more is now known of its nature. The relationship of the carbonaceous sandy shale to other Older Tertiary sediments south-east of the mouth of the Gellibrand River, is herein recapitulated in the light of further advances in our knowledge of Victorian Older Tertiary geology. A revised stratigraphical nomenclature has been employed in an attempt to simplify the naming of parts of the sedimentary succession, and to bring the nomenclature into general conformity with the principles of the current Australian Stratigraphic Code (Raggatt, 1950).

Nature, Fossil Content and Relationships of the Deposits

Where sampled, at Wilkinson's No. 8 specimen locality (see Baker 1943, fig. 1, p. 238), the carbonaceous sandy shale constitutes the lower 25 feet of the cliff face, the base of which is masked by recent beach sands that are here some five feet above normal high tide level. This bed of carbonaceous sandy shale occurs in the

J

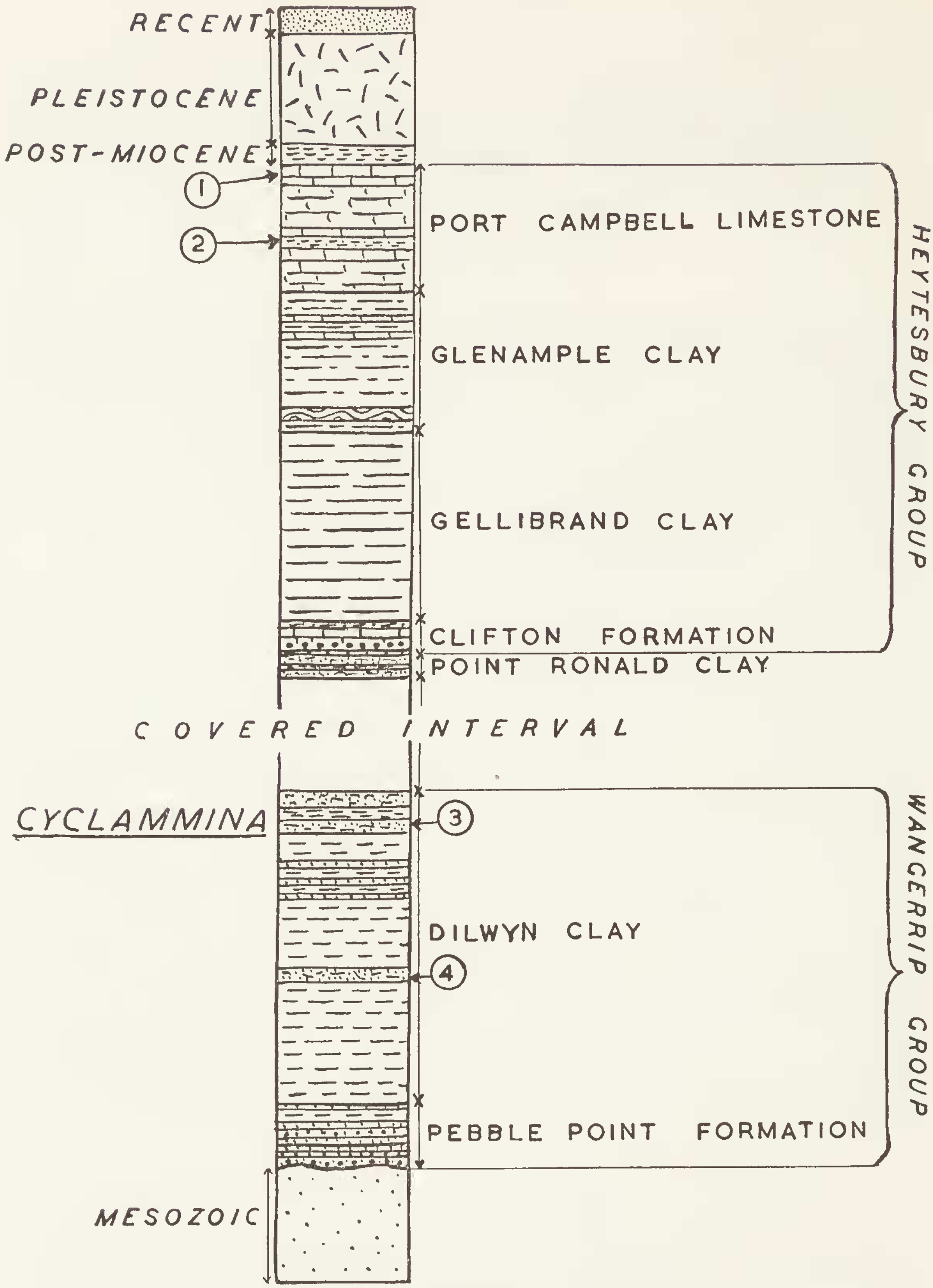

FIGURE 1.

Stratigraphical Column showing conformable relationship of *Cyclammina*-bearing carbonaceous sandy sediments to overlying and underlying sediments. 1 = Peterborough Member; 2 = Rutledge's Creek Member; 3 = Princetown Member (*Cyclammina*-bearing); 4 = Rivernook Member. (Thicknesses of the various formations can be assessed from Baker 1950, figure 2, p. 29.)

uppermost part of a series of conformable Older Tertiary sediments that dip at up to 5° in a direction a little north of west. The deposit comprises portion of the beds previously named the Princetown Beds recently placed in the Latrobe Formation (Baker 1950, p. 30), but now included in the Wangerrip Group and named the Princetown Member of the Dilwyn Clay (see fig. 1). Ferruginous sandy and clay layers above the Princetown Member, have so far yielded no fossils, and are overlain to the north-west by Pleistocene dune limestone that constitutes a covered interval masking the relationships between younger Tertiary sediments north-west of the mouth of the Gellibrand River and Older Tertiary sediments south-east of the Gellibrand River. To the south-east, the Princetown Member is conformably underlain by carbonaceous clays and shales previously termed "algal clays with copiapite" (Baker 1943, fig. 2, p. 243) in accordance with the nomenclature used in the past for branching markings regarded as being "presumably algal" (Singleton 1941, p. 25). Some of these markings, if not all, are now regarded as non-algal. In the upper part of the Dilwyn Clay, the so-called "algal" clays are interbedded with thin, hard sandstone beds, one of which contains, among other fossils, *Cycloseris tenuis* Duncan (see Baker 1943, p. 240), a coral having an Eocene age in southern France and an Upper Cretaceous to Eocene age in other parts of the world (Felix 1927). Further to the south-east, the Dilwyn Clay contains the interbedded Eocene Rivernook Member, and then passes into the conformable littoral deposits comprising the Pebble Point Formation (Baker 1943, pp. 241-242, Baker 1944, p. 87, Singleton 1943 and Teichert 1943).

Until recently, the carbonaceous sandy shale bed (Princetown Member) at Wilkinson's No. 8 specimen locality has been classed as unfossiliferous, and it has been somewhat uncertain whether the deposit was of marine origin. Lithological and mineralogical resemblances to the carbonaceous sandy beds near Anglesea (Baker 1944, p. 87) which contain marine fossils (Edwards and Baker 1951, p. 44), have led to the belief that the carbonaceous sandy shale south-east of the Gellibrand River was probably of similar age and probably also of marine origin.

Recent falls of large slabs of the carbonaceous sandy shale from steep cliff exposures three-quarters of a mile south-east of the mouth of the Gellibrand River, have now revealed the presence of poorly preserved fragments and a few readily recognizable cross sections of *Cyclammina;* also rare moulds of pelecypods that are largely indeterminate. One external mould, however, has the oval to trigonal shape, the size and the concentric growth lines suggestive of a *Nucula* or *Nuculana*, although it cannot be specifically compared with *Nuculana paucigradata* Singleton (Singleton 1943) described from the Pebble Point Formation. Another pelecypod mould has the shape and size of *Cucullaea* (*Cucultona*) *psephea* Singleton (Singleton 1943) also described from the Pebble Point Formation. Occasional impressions of the corallum and septae of *Trochocyathus* are preserved in occasional pyritic nodules in the deposit; they resemble the better preserved examples of this coral that is so abundant in the stratigraphically lower sandstone bed containing *Trochocyathus, Odontaspis,* etc.

Cyclammina

The specimens of *Cyclammina* are composed of small, loosely attached grains of quartz that tend to crumble away on exposure, hence it is not surprising that the presence of *Cyclammina* in the carbonaceous sandy shale went unrecognized for some time. Many of the foraminiferal remains are represented merely by subcircular aggregates of small, whitish quartz grains and show no distinct fossil structures. A few specimens exposed as cross sections in the freshly fractured rock are multilocular, and reveal thick-walled, arenaceous forms having concave septae (typical of the "nautiloid" varieties of the foraminifera) and a planispiral arrangement of chambers that are filled with matrix similar to the containing carbonaceous sandy shale; no apertures were evident in any of the specimens discovered, because the forms could not be isolated from the matrix without crumbling. Mr. A. C. Collins has kindly verified this determination of *Cyclammina.*

Branching Markings.

Branching markings resembling in colour and shape the so-called "algal" markings in the upper portions of the Dilwyn Clay, are much more sparse in parts of the carbonaceous sandy shale composing the Princetown Member. Inasmuch as they consist of slender, lighter coloured aggregates of mineral matter from which the carbonaceous, etc., content has apparently been abstracted, and are pipe-like markings without any definite plant-like structures, they are now thought to be possibly due, in large measure, to burrowing organisms (cf. Baker 1944, p. 91).

Iron Sulphide Nodules

Occasional nodules of iron sulphide, similar to the nodules in the carbonaceous sandy beds at Point Addis near Anglesea, are up to three inches in length and are likewise composed of pyrite rather than marcasite (Edwards and Baker 1951, pp. 40-45).

The iron sulphide in the Princetown Member has replaced a few macrofossils as in the deposits near Anglesea, and occasional structures revealed in polished surfaces of the pyrite, are suggestive of bryozoal fragments. Similar genera, however, have not yet been observed at each locality, in the iron sulphide nodules. The nodules are not all composed of massive pyrite throughout, and in parts they enclose small areas of unreplaced carbonaceous sandy shale. Elsewhere, the pyrite in the nodules acts as a cementing medium to detrital grains, just as in the thin bands of pyrite from 2,910 feet in the Nelson Bore at Glenelg in Western Victoria, and as in nodules at Point Addis and in the Lower Eocene Pebble Point Formation. The detrital grains consist largely of sub-angular to sub-rounded quartz grains with occasional rutile grains; these are set in a matrix of pyrite where the clay constituents of such parts of the rock have been completely replaced by pyrite. Narrow threads of pyrite have also penetrated along cracks in some of the quartz and rutile grains. Some of the elongated "nodules" in the Pebble Point Formation consist of pyrite infilling cell structures and replacing the wall tissues of fossil wood. Such have not so far been observed in the Princetown Member, although rare fragments of partially coalified wood are present.

Discussion

Although *Cyclammina* generally has little value as an index fossil (cf. Glaessner 1951, p. 278), its presence in Victorian Older Tertiary deposits has been used in the past for correlation with the *Cyclammina*-bearing beds near Anglesea, i.e. with sediments previously regarded as of Oligocene age. Because of its time range (from Cretaceous to Recent), no stratigraphical value can be attached to its occurrence in the Princetown Member, but its presence here provides a further factor pointing to similarity with the carbonaceous sandy beds near Anglesea and establishes the poorly fossiliferous Princetown Member as being of marine origin.

Glaessner and Parr (see Baker 1943, appendix, p. 252) found no examples of *Cyclammina* in the foraminiferal assemblage so far recognized from the lowest sediments (the Pebble Point Formation) exposed in the Lower Eocene to Paleocene rocks of the Princetown district. Although various other parts of the Dilwyn Clay were searched for *Cyclammina*, both by the late W. J. Parr and by the author, no foraminifera were discovered. Even if *Cyclammina* should occur in these clays below the Princetown Member, it would not necessarily indicate an Oligocene age, because of its time range, and because the evidence of the shelly fauna in the inter-bedded sandstones is more specifically indicative of a Lower Eocene age for the Group as a whole.

Because the pelecypod moulds in the Princetown Member cannot be directly compared with the pelecypod shells in the Pebble Point Formation, although their shape and size are suggestive of similarities, no importance can be attached to them as far as an age determination is concerned, but being impressions of marine organisms, they further attest the marine origin of the Princetown Member. The same applies to the impressions of corals in the contained pyrite nodules.

The fact that the copiapite-bearing Dilwyn Clay contains branching markings like those in the stratigraphically higher Princetown Member, which is also gypsum- and copiapite-bearing, might suggest the possibility of a similar age, especially in view of the absence of really distinctive fossils from both deposits and the poorly fossiliferous character of each. However, no especial importance is attached solely to the similarity of these markings from the aspect of age correlation, because numerous markings of various size and shape, now mostly regarded as due to burrowing organisms, occur in various parts of the Moonlight Head-Princetown-Port Campbell-Peterborough Tertiary sequence, including the Eocene to Paleocene Pebble Point Formation, the Eocene Dilwyn Clay and its contained Princetown Member, and several of the Miocene formations (e.g. the Glenample Clay) situated east and west of Port Campbell (cf. Baker 1944, p. 91). The larger of these branching markings occur in sandy phases of the Pebble Point Formation and have been shown to possibly result from *Callianassa* (Glaessner 1947, p. 6). More slender markings in the younger Tertiary deposits are evidently probably due to marine worms, but rather larger markings in the Miocene sediments are possibly due to mud-haunting spatangoids and mud-haunting crabs that are found fossil in several of the deposits north-west of the mouth of the Gellibrand River (Baker 1944).

Recently, (Baker 1943, 1950) the tendency has been to place the upper portions of the Dilwyn Clay into the Eocene. With the discovery of *Cyclammina* in the Princetown Member, this carbonaceous sandy shale deposit becomes even more closely allied in character to the carbonaceous sandy deposits near Anglesea. It was because of the general similarity between the two deposits—one at Anglesea and the other, the Princetown Member, near Princetown, that the Latrobe Formation was originally separated from the underlying sediments now classed as the Dilwyn Clay, and the Latrobe Formation thus became regarded tentatively as Oligocene in age (Baker 1950, p. 30). In view of the conclusions reached in this paper, the term "Latrobe Formation" can now be dropped completely from usage in this area, and the Princetown Member included in the top of the Dilwyn Clay, Wangerrip Group.

Lithologically and mineralogically, there is virtually no significant difference between the Princetown Member and the upper parts of the Dilwyn Clay, nor for that matter throughout the Dilwyn Clay itself. Most variations are generally apparent only, and assignable largely to variability in degree of oxidation from place to place. Interbedded in the Dilwyn Clay are (a) the Eocene Rivernook Member, which is situated approximately half-way up from the base of the Wangerrip Group, and (b) the Eocene fossiliferous sandstone bands (one containing *Trochocyathus* and *Odontaspis,* etc., and the other containing "*Turritella*", etc.) which are situated nearer the top of the Wangerrip Group. Thin layers of clay similar to the major component of the Dilwyn Clay are interbedded with the upper sediments comprising the Pebble Point Formation (Baker 1943, p. 237; 1950, p. 20).

Summing up, the following observations have a distinct bearing upon the relationships of the *Cyclammina*-bearing Princetown Member to the Older Tertiary sediments south-east of the mouth of the Gellibrand River:

(i) All the beds in the sequence from the base of the Pebble Point Formation up to and including the ferruginous sandstone and clay above the Princetown Member are conformable with one another, having similar dips in similar directions.

(ii) The Princetown Member and other parts of the Dilwyn Clay are essentially similar lithologically and mineralogically, are both poorly fossiliferous and both contain iron sulphide nodules with occasional fragmental bryozoal structures.

(iii) Mineralogically, the sandy and gritty phases of the Lower Eocene to Paleocene Pebble Point Formation are essentially similar to the sandstone bands with fossils that are interbedded with the upper portions of the Dilwyn Clay. Glauconite in particular is common to all of these sediments.

(iv) Some bands in the Dilwyn Clay contain branching markings due largely to burrowing organisms, and these are similar to markings in the Princetown Member.

(v) The sandstone bed with *Trochocyathus, Odontaspis,* etc., the sandstone bed with "*Turritella*" and the Rivernook Member that are all interbedded with the Dilwyn Clay (see fig. 1), contain certain gasteropods that are essentially the same as gasteropods in the Lower Eocene to Paleocene Pebble Point Formation. Moreover, others of the mollusca in these fossiliferous horizons are common to more than one of the horizons (*fide* O. P. Singleton).

(vi) The shelly faunas of the Wangerrip Group are entirely distinct from those of the Upper Eocene at Brown's Creek near Johanna River (*fide* O. P. Singleton), and are entirely distinct from all subsequent Tertiary deposits in Victoria.

(vii) As noted by Glaessner (1951, p. 277), "the fauna (i.e. of the more richly fossiliferous members higher in the Wangerrip Group) resembles that of the Pebble Point Formation, but the distinctive species of these beds have not been found".

(viii) *Callianassa* sp. has recently been found in beds stratigraphically higher than the Pebble Point Formation and the Rivernook Member (from which beds they were originally described by Glaessner in 1947), the sandstone bed containing *Trochocyathus, Odontaspis,* etc., also having an occasional propodus of this decapod crustacean.

(ix) The interbedded Rivernook Member has a foraminiferal assemblage regarded by W. J. Parr (see Baker 1944, pp. 86-87) as similar to that of the Pebble Point Formation.

The sum total of this evidence is interpreted to indicate that all of the Older Tertiary deposits south-east of the mouth of the Gellibrand River belong to one Group that is probably virtually much the same age throughout, namely, Lower Eocene to Paleocene, the age assigned recently (Baker 1943 and 1950, Singleton 1943, Teichert 1943) to only the lower beds (Pebble Point Formation) in the Wangerrip Group. Since the Princetown Member in the Wangerrip Group thus comes to be regarded as Lower Eocene in age, and is shown herein to be closely allied in many characteristics to similar beds exposed in the cliffs near Anglesea, it follows that there is a distinct possibility that the carbonaceous sandy sediments of the Anglesea district may be older than Oligocene.

In the Princetown district, the relationship of the Eocene sediments (Wangerrip Group) to the younger (Oligocene to Miocene) Heytesbury Group that extends from just north-west of the mouth of the Gellibrand River to beyond Peterborough, is unfortunately masked beneath a covered interval (Baker 1950), and any erosional break or possible faulting that might exist in this critical portion of the Tertiary sequence is likely to be under the covered interval, indicated in the following stratigraphical column (fig. 1). This column shows the position of the *Cyclammina*-bearing Princetown Member in relation to beds above and below. For convenience of reference, the stratigraphical column presented in an earlier publication (Baker 1950, p. 29) is reproduced herein, with amendments to the nomenclature:

References

Baker, G., 1943. Eocene Deposits South-east of Princetown, Victoria. *Proc. Roy. Soc. Vic.*, lv (2), n.s., pp. 237-254.

——, 1944. The Geology of the Port Campbell District. *Ibid.* lvi (1), n.s., pp. 77-108.

——, 1950. Geology and Physiography of the Moonlight Head District, Victoria. *Ibid.* lx, n.s., pp. 17-43.

Cookson, I. C., 1953. Records of the Occurrence of *Botryococcus braunii, Pediastrum* and the Histrichosphaerideae in Cainozoic Deposits of Victoria. *Mem. nat. Mus., Melbourne,* this volume, pp. 107-123.

Edwards, A. B., and Baker, G., 1951. Some Occurrences of Supergene Iron Sulphides in Relation to their Environments of Deposition. *Journ. Sed. Petr.* vol. 21, pp. 34-46.

Felix, J., 1927. Fossilium Catalogus. *Anthozoa Miocaenica* (1), 35.

Glaessner, M. F., 1947. Decapod Crustacea (Callianassidae) from the Eocene of Victoria. *Proc. Roy. Soc. Vic.,* lix (1), n.s., pp. 1-7.

——, 1951. Three Foraminiferal Zones in the Tertiary of Australia. *Geol. Mag.,* lxxxviii, pp. 273-283.

Raggatt, H. G., 1950. Stratigraphic Nomenclature. *Austr. Journ. Sci.,* 12 (5), pp. 170-173.

Singleton, F. A., 1941. The Tertiary Geology of Australia. *Proc. Roy. Soc. Vic.,* liii (1), n.s., pp. 1-125.

——, 1943. An Eocene Molluscan Fauna from Victoria. *Ibid.* lv (2), pp. 266-281.

Teichert, C., 1943. Eocene Nautiloids from Victoria. *Ibid.* lv (2), pp. 259-265.

Acknowledgment.

The author is indebted to O. P. Singleton, Ph.D., for reading the manuscript and discussing the Older Tertiary sequence of the critical areas east and west of the Cape Otway region on the southern coast of Western Victoria.

Appendix

Since this article went to the press, a preliminary note has been published in the Australian Journal of Science (vol. 14, April, 1952, pp. 143-147), on the "Geology of Tertiary Rocks between Torquay and Eastern View, Victoria", wherein reference is made by the authors, H. G. Raggatt and I. Crespin, to the occurrence of *Cyclammina* in the top 30 feet of purplish-grey fine silty sandstone at Dilwyn Bay, eight miles west of Johanna River.

Dilwyn Bay is in the Moonlight Head district (see Baker 1950 —reference list above). The sediments in which Raggatt and Crespin record a new discovery of *Cyclammina,* are partially oxidized portions of the Dilwyn Clay of this paper. The discovery serves to extend the range of occurrence of *Cyclammina* to lower horizons in the Dilwyn Clay than the *Cyclammina*-bearing carbonaceous sandy shale horizon (Princetown Member) described in this paper.

The sites of discovery of these two occurrences of *Cyclammina*-bearing sediments are two and a quarter miles apart. At each locality, these sediments are members of the same series of strata that outcrop continuously in the cliff sections of the district. All the strata have the same low dip values (up to 5°) in the same direction (north of west). On this basis, it can be estimated that the *Cyclammina*-bearing horizons are separated by a stratigraphical thickness of approximately 550 feet, because faulting in the area is on too small a scale to appreciably affect the calculations, and there is no evidence of repetition of strata due to other causes. Although similar deposits occupy much of the area between these two localities, they have not yet been shown to contain *Cyclammina,* although they do contain occasional shells and shell fragments as well as bryozoa (in pyrite nodules), and are thus marine. Interbedded in the Dilwyn Clay, however, are fossiliferous sandstone members containing better preserved molluscs and decapod crustaceans which are also found in the Lower Eocene to Paleocene deposits comprising the Pebble Point Formation in the Moonlight Head-Princetown district.